NEC

Application Note

V850 Standby Modes

V850ES/SG2
V850ES/SJ2

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NOTES FOR CMOS DEVICES

① **VOLTAGE APPLICATION WAVEFORM AT INPUT PIN**

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② **HANDLING OF UNUSED INPUT PINS**

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ **PRECAUTION AGAINST ESD**

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ **STATUS BEFORE INITIALIZATION**

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

⑤ **INPUT OF SIGNAL DURING POWER OFF STATE**

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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Introduction

Readers

This application note is intended for users who want to understand the functions of the and similar V850 derivatives.

Purpose

This application note presents the hardware application note of the .

Organization

This system specification describes the following sections:

- Overview
- Operation
- Software functions

Legend

Symbols and notation are used as follows:

Weight in data notation	:	Left is high-order column, right is low order column
Active low notation	:	$\overline{xxx}$ (pin or signal name is over-scored) or /xxx (slash before signal name)
Memory map address:	:	High order at high stage and low order at low stage
Note	:	Explanation of (Note) in the text
Caution	:	Information requiring particular attention
Remark	:	Supplementary explanation to the text
Numeric notation	:	Binary . . . xxxx or xxxB Decimal . . . xxxx Hexadecimal . . . xxxxH or 0x xxxx

Prefixes representing powers of 2 (address space, memory capacity)

K (kilo) : $2^{10} = 1024$

M (mega) : $2^{20} = 1024^2 = 1,048,576$

G (giga) : $2^{30} = 1024^3 = 1,073,741,824$

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Chapter 1 Overview

1.1 Standby modes - Overview

Several standby modes are supported by V850 microcontrollers in order to reduce the power consumption of the device. In standby modes either the clock or power supply to some functional parts of the device are switched off. Alternatively a slower operating clock can be selected to reduce power consumption.

Although the usage of the standby modes is similar for most V850 devices please check the user's manual for the individual device before applying the method to other microcontrollers than V850ES/Sx2 which is used as reference in this application note.

The standby modes supported in V850ES/Sx2 are:

- HALT
- IDLE 1
- IDLE 2
- STOP
- Subclock Operation Mode
- Sub IDLE Mode

This application note shows the general use of V850 standby modes.
As examples the HALT, STOP and Subclock modes are shown in examples.
Other standby modes can be set easily by modifiying the given examples.

Chapter 2 Operation

2.1 Function of Standby Modes

The general function of the individual standby modes is as follows:

2.1.1 HALT Mode

In HALT Mode the clock supply to the CPU is stopped and therefore no instruction executen takes place anymore. HALT mode is entered by executing a dedicated assembler instruction ("HALT").

2.1.2 IDLE Modes

IDLE Modes are entered by setting the Power Save Mode Register (PSMR) and Power Save Control Register (PSC) accordingly. In Idle modes the clock supply to the CPU and to most peripherals is cut thus reducing the power consumption of the microcontroller. In contrast to IDLE 1 Mode the clock supply to PLL and flash memory are cut additionally in IDLE2 Mode which reduces the power consumption even more.

2.1.3 STOP Mode

In STOP Mode the main oscillator is stopped and therefore the clock supply to the CPU and most peripherals is stopped thus reducing the power consumption to a minimum. STOP mode is entered by setting the Power Save Mode Register (PSMR) and Power Save Control Register (PSC) accordingly.

2.1.4 Subclock Operation Mode

In Subclock Operation Mode the CPU operation clock is switched to the subclock oscillator and therefore the CPU operates instructions at 32.768kHz rather than at the clock frequency of the main oscillator or the PLL output frequency. As execution speed is reduced very much in this mode, the power consumption is reduced too. In Subclock Operation Mode it is possible to switch off the main oscillator by software. Subclock Operation Mode is entered by configuring the Processor Clock Control Register (PCC) accoringly.

2.1.5 Sub-IDLE Mode

When the microcontroller operates in Subclock Operation Mode the power consumption can be reduced further by entering Sub-IDLE-Mode. When the main clock is switched off in Subclock Operation Mode and then Sub-IDLE Mode is entered the power consumption can be reduced to a level as low as STOP mode. When waking up from Sub-IDLE Mode the microcontroller enters Subclock Operation Mode.

Chapter 3 Software Functions

3.1 Demonstration Software

The demonstration software shows the function of the following standby modes:
- HALT Mode
- STOP Mode
- Subclock Operation Mode

Other operation modes operate very similar to the above and can be implemented by simple modifications of the demonstration software.

3.2 Software Structure

The demonstration software contains the following parts:

- **powersave_halt()**

This routine is used for entering HALT mode. The HALT mode is entered using the "HALT" instruction within this routine.

- **powersave_stop_prepare()**

routine preparing for entering STOP mode. STOP mode is entered by an assembler function

- **_powersave_stop**

This is an assembler routine which is called by powersave_stop_prepare(). It modifies the Power Save Mode Register (PSMR) and the Power Save Control Register (PSC).

- **_powersave_sub**

This routine switches to subclock operation and switches off the main clock afterwards.

- **_powersave_main**

This routine is used to wake up from subclock mode. First the main clock is re-started and next operation is changed from subclock to main clock operation after the oscillation stabilization time has passed.

To make the demonstration software operate in a complete project some further functions are required. Although they do not mainly demonstrate the function of the standby modes they are described shortly below in order to help understand the function of the whole demonstration project.
The further parts of the demonstration software are:

- **main()**

Contains the basic system initialization, peripheral initialization and selection of the operation mode to be demonstrated.

- **init_ports()**

Initialization of microcontroller ports to faciliate analyzation of the operation modes. If the code is run on the V850ES/SG2 starter kit some data can be output on the 7-segment display and the keys of the board can be used t**o wake up the microcontroller from the HALT or STOP mode.**

- **init_port_cm()**

Initialization of the port cm at which the CLKOUT signal can be output to monitor the CPU operation frequency using an oscilloscope.

- **segout()**

Function delivering a code to output a count value for the 7-segment display output. This is used to show that the microcontroller is active after wake up from the standby mode.

- **intp0() and intp1()**

Interrupt service routines. The interrupt signals for these routines are used to wakeup the microcontroller from the standby modes. The ISRs themselves are not used in this application.

- **INTTP0CC0**

Interrupt service routine used for counting in order to show that the device operates correctly after wakeup from standby mode.

3.3 Demonstration Software Usage

The demonstration software uses #defines to select the standby mode to demonstrate. The user can select between the following modes:

- mode_normal
- mode_stop
- mode_halt
- mode_subclock

3.3.1 mode_normal

This is the normal operation mode. Here no standby mode is entered. This mode can be used to check the system operation under normal conditions in order to compare the behaviour with the function if a standby mode is selected.

3.3.2 mode_stop

If this mode is selected the software will go into STOP mode after program start.
Before going into STOP mode the contents of the interrupt masks for all interrupt sources are backed up. This method is used to demonstrate how to reduce the number of wakeup sources in the standby mode. In general the standby mode can be released by any unmasked maskable interrupt (and RESET and NMI). In the demonstration system also a timer interrupt is running. This timer interrupt should not wake up the microcontroller from standby mode. Instead only the pin interrupts INTP0 and INTP1 (and RESET) shall be allowed to wake up the microcontroller. So before entering the standby mode the other interrupt sources are blocked. After the standby mode is released the original interrupt status is restored.
The STOP mode is entered using an assembler function. To enter STOP mode first the standby mode to be entered must be selected using the Power Save Mode Register (PSMR). Next the STOP mode is entered using the Power Save Control Register (PSC).
After entering a standby mode a sequence of 5 NOP instructions must be entered in the code. This is also shown in the example. The code execution will stop here. After the standby mode is cancelled (in this case by executing the INTP0 or INTP1 pin interrupt) program execution will continue from here.
After the STOP mode is released the program execution continues normally. This can be seen from the timer interrupt continuing to operate and counting up numbers on the 7-Segment display connected to Port 9 of the V850ES/SG2 starterkit hardware.

3.3.3 mode_halt

If this mode is selected the software will go into HALT mode after program start.
In general the standby mode can be released by any unmasked maskable interrupt (and RESET and NMI). In the demonstration system also a timer interrupt is running. This timer interrupt should not wake

up the microcontroller from standby mode. Instead only the pin interrupts INTP0 and INTP1 (and RESET) shall be allowed to wake up the microcontroller. So before entering the standby mode the other interrupt sources are blocked. After the standby mode is released the original interrupt status is restored.
The HALT mode is entered using the assembler instruction “HALT”. After entering a standby mode a sequence of 5 NOP instructions must be entered in the code. This is also shown in the example. The code execution will stop here. After the standby mode is cancelled (in this case by executing the INTP0 or INTP1 pin interrupt) program execution will continue from here.
After the HALT mode is released the program execution continues normally. This can be seen from the timer interrupt continuing to operate and counting up numbers on the 7-Segment display connected to Port 9 of the V850ES/SG2 starterkit hardware.

3.3.4 mode_subclock

If this mode is selected the software will enter Subclock mode using the assembler function “_powersave_sub”. In this function the subclock crystal frequency of 32.768kHz is selected as the operation clock for the CPU. A crystal of 32.768kHz must be connected to the XT1 and XT2 pins of the microcontroller.
Next after the CPU operation has switched to subclock operation the main clock is switched off. This will reduce the power consumption to a very level. The CPU is now running in subclock mode and executes its instruction at low speed. A port (P50) is set to detect this point using an oscilloscope.
Next the CPU operation is switched back to main clock operation. This is done in the assembler function “_powersave_main”. First the main clock is started. Here the oscillation stabilization time must pass before the main clock signal can be used to drive the CPU. In contrast to the startup after a RESET or STOP mode call where this is done automatically this must be done in a software loop when switching on the CPU clock supply by software using the PCC register. After the main clock operates properly the CPU is switched back to operation on main clock. A port (P50) is cleared to detect this point using an oscilloscope.

Appendix A Reference Documentation

Item	Document No.	Document Title
1	U16603EJ	V850ES/SJ2 Hardware (User's Manual)
2	U16541EJ	V850ES/SG2 Hardware (User's Manual)
3	U15943EJ	V850ES Architecture (User's Manual)

Appendix B Revision History

Item	Date pulished	Document No.	Comment
1	June 2007	U18825EE1V0AN00	New List